AMERICAN ORTHOPEDIC SURGERY: THE FIRST 200 YEARS

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THE word "orthopaedy" was deliberately created by Nicholas Andry, professor of medicine at the University of Paris, to serve as the title of a book on the prevention and correction of musculoskeletal deformity which he published in 1741. The popularity of Andry's treatise was immediate, and English, German, and Italian translations appeared within two or three years. The title was taken from two Greek words, *orthos* (straight) and *paidion* (child). Andry was not the first to be concerned with the clinical subject, but his book and his high position in the profession inspired intense interest which has not abated.

For more than a century the term "orthopedics," variously spelled, represented an interest in musculoskeletal deformity and disease in the practice of many physicians and surgeons. Not until the middle of the 19th century did orthopedics really become an exclusive specialty. The American Orthopedic Association was organized in 1887; the more inclusive American Academy of Orthopaedic Surgeons was not launched until 1933.

American orthopedics in its early years was based on that of England, Scotland, and France, since many of our first teachers and professors had made "grand tours" to the leading clinics of those countries. Among the names that are found in early American orthopedic literature—and often in correspondence published in the foreign literature—were those of John Warren and his son, John Collins Warren of Boston; Philip Syng Physick and John K. Mitchell of Philadelphia; Dixie Crosby and Nathan R. Smith of Dartmouth, N.H.; and Walter Brashear of Maryland. These men all appear in the general history of American surgery; they are noted in early orthopedics chiefly for

their major disarticulations and joint resections, performed in an era when such measures were heroic and rare.

American orthopedics as a specialty began in Boston with John Ball Brown (1784-1862) and his equally famous son, Buckminster Brown (1819-1891). John Ball Brown, after a period of work in general practice, became so concerned with the then generally neglected field of skeletal deformity—those then called the crippled and deformed —that he finally confined his practice entirely to such patients. It must be emphasized that the basic and often the entire treatment of skeletal deformity then consisted of braces and physical manipulation. Plaster of Paris was added later. Until well into the 20th century, surgical procedures such as osteotomy or tenotomy were used occasionally but to orthopedists these served only as a supplement to basic mechanotherapy. Therefore, until the most recent decades the brace maker was very much a part of the orthopedic clinic and the orthopedist's private office. In order to carry out his manipulations and to design, correct, and adjust his braces, the elder Brown needed more than an office. In 1838 he opened the Orthopaedic Infirmary, a Hospital for the Cure of Deformities of the Human Frame, later renamed the Boston Orthopaedic Institution. Its reputation as a center exclusively devoted to deformed children and adults grew rapidly and patients were brought from all parts of the United States. John Ball Brown's dedication to orthopedics has been ascribed to the loss of his elder son in 1837 from spinal disease and to the severity of the spinal deformity in his second son, Buckminster Brown, who succeeded him despite the disability.

In 1845 the Institution had an outpatient infirmary and about 60 inpatient beds. John Ball Brown's treatment was advertised as that used by the most advanced clinics of Europe; it was announced that a volunteer attending staff from Harvard University and the Massachusetts General Hospital was available in addition to the Browns. Although the treatment was mainly mechanical and involved the use of adjustable braces, traction, and daily manipulation, the Institution was among the first to use Stromeyer's subcutaneous tenotomy for clubfoot and Guérin's tenotomy for scoliosis and, later, for torticollis. Brown considered tenotomy merely an aid to mechanotherapy. Apparently the first recorded tenotomy for clubfoot in the United States was performed at the Boston Orthopaedic Institute on February 21, 1839. Stromeyer had reported his cases in 1831.

Doubtless Buckminster Brown (1819-1891) was aided by his father. He received his M.D. at Harvard University in 1844. In 1845 and 1846 he visited the leading orthopedic centers of Europe. He spent time with William John Little in London, Alphonse Guérin and Sauvier-Henry-Victor Bouvier in Paris, and Georg Friedrich Stromeyer in Hanover. Although he learned their techniques of tenotomy, he retained his father's conservatism and was more interested in braces and other mechanical methods. Returning to Boston, he entered general practice for a short time, in conformity with custom. Gradually he devoted more and more attention to orthopedics in association with his father at the Boston Orthopaedic Institution. In 1861 he undertook the added responsibility of 24 beds at the House of the Good Samaritan, the first children's hospital in the United States. He soon became chief surgeon there and retained this post until he retired in 1880.

Buckminster Brown's dedication to orthopedic surgery was intensely personal, being influenced by his own embarrassment as a hunchback; his kyphoscoliosis was at times disabling and painful. He had come down with Pott's disease at the age of 14 and had spent most of the next eight years in bed. However, born to Boston's elite, he found no difficulty having his training and abilities rewarded. With his father he published the first American book on orthopedics. In 1858 he fashioned a spinal brace similar to that later known as the Taylor brace. In 1887 he became a charter member of the American Orthopaedic Association. On his death in 1891 he left $40,000 to establish a chair of orthopedics at Harvard University; its occupant still bears the title of John Ball and Buckminster Brown Orthopedic Professor.

During the early decades of the republic orthopedic innovations in the European centers appeared in the United States as quickly as in major continental capitals. After at least a century of polemics in the treatment of pyarthrosis and osteomyelitis (tuberculous or other), the most dramatic advance in orthopedic surgery in the early 19th century was the reintroduction and popularization of subcutaneous tenotomy in the 1830s. Although John Ball Brown is credited with publishing the first report of this procedure in the United States in 1839, David L. Rogers in New York City and Dickson in North Carolina had demonstrated the method in 1834. This was referred to by Detmold; Dickson did not publish his cases. However, the operation was not generally accepted until Brown's reports appeared.

Philip Syng Physick of Philadelphia (1768-1837), professor of surgery at the University of Pennsylvania Medical School, was a surgeon of wide accomplishments. Among his many contributions was the first original surgical procedure in the field of orthopedics developed in the United States. In January 1822 he was faced with a case of ununited fracture of the humerus. At that period, the patient who had nonunion of a fractured long bone either lived with his disability or accepted one or more attempts at open operation, with removal of excess callus and scraping of the fracture surfaces. This often led to chronic osteomyelitis and draining sinuses. Physick decided to pass a seton through the skin in order to irritate the granulomatous or fibrocartilaginous tissues in the interfragmental area. Apparently his first attempt was successful. He reported the case and spoke of it, and for a time the "American method" of activating nonunion without open operation was widely known. Of course, it met with resistance when numbers of unsuccessful cases became known and closed infections appeared. But the concept of activating or stimulating the ends of the fragments in retarded union or nonunion remained. Physick also attempted to improve the hip splint by carrying the side bar up to the axilla.

The second and far more influential American contribution to orthopedics was offered by John Rea Barton of Lancaster and Philadelphia (1794-1871). Barton was a younger contemporary of Physick and also served at the medical school of the University of Pennsylvania. In 1826 he was consulted by a man who suffered from ankylosis of the hip, a sequel of infection; the patient had a severe flexion-adduction deformity. At that time the usual treatment was corrective osteotomy, the limb being immobilized until union occurred in a more suitable position. Barton performed an infratrochanteric osteotomy, but instead of immobilizing the limb he actively mobilized the hip as soon as this was tolerable, and he kept it mobile. In fact, he deliberately produced a pseudoarthrosis near the region of the joint. In concept and in fact this was the first recorded arthroplasty; it was successful as long as the patient continued to exercise. Barton's report of the case appeared in 1827 in the *North American Medical and Surgical Journal.* It was soon noticed in the leading European journals and in several textbooks. This procedure, originally conceived as a deliberate postosteotomy pseudoarthrosis, was adopted universally and became the forerunner of arthroplasty, one of the most studied experimental techniques of orthopedics.

Although the term orthopaedy had been in use since 1741, with a few exceptions—Jean André Venel in Switzerland, Johann Georg von Heine in Germany, and the Browns of Boston—the specialty did not gain recognition until the mid-19th century. In 1837 William Ludwig Detmold (1808-1894), a former surgeon of the Royal Hanoverian Guards, arrived in New York City and entered practice; he confined his work almost entirely to the care of skeletal deformities. He was the first European to arrive properly trained in the specialty. He had studied with Stromeyer and brought his teacher's methods with him. His first published paper dealt with the treatment of clubfoot by tenotomy followed by bracing. In 1841 Detmold established a clinic for crippled children at the College of Physicians and Surgeons and he continued it until 1861. He became a surgeon in the Army of the United States during the Civil War and at that time devised the Detmold knife, a combination knife and fork to be used by one-armed veterans. The college appointed him professor of military surgery and hygiene from 1862 to 1865, and then professor of clinical and military surgery. He also accepted appointments at the Bellevue and Presbyterian Hospitals and became a charter member of the New York Academy of Medicine. He was a founding member of the New York County Medical Society and its first president. Detmold's importance to American orthopedics lay not in personal clinical innovations; indeed, it was he who credited Dickson and Smith for their early Stromeyer tenotomies, which were done in 1836. He was the first of a new breed in American medicine, the trained and self-declared orthopedic surgeon, who had started practice as such, and who by publication, teaching, and lecturing inspired other physicians to practice the specialty and medical institutions to accept it.

Samuel David Gross (1805-1884), professor of surgery at the Jefferson Medical College in Philadelphia, revolutionized the clinical management of fractures of the long bones by the application of adhesive tape. In 1852 Antonius Mathijsen, a Flemish army surgeon, had also changed the treatment of fractures and the practice of orthopedic surgery by his introduction of the plaster of Paris cast. In orthopedics this material vied with adhesives for several decades, especially in the United States, where it soon replaced braces. This occurred long before plaster won wide acceptance in Europe.

In 1861 Gordon Buck of New York City (1807-1877) added the

old use of pulley traction to Gross' adhesive straps and designed the simple but eventually ubiquitous Buck's extension traction, which has become the traction system most frequently applied in orthopedics and traumatology. In 1857 Joseph Pancoast of Philadelphia (1805-1882) attempted the reduction and maintenance of long-bone fractures by inserting iron screws through the fragments of oblique fractures, a technique which has been attempted repeatedly with nonelectrolytic metal screws ever since.

In the same year, 1857, Henry Gassett Davis (1807-1896), another of New York City's leading surgeons, devised an elastic material for traction which came into use as an improvement over Gross' adhesive strap. Either could be used for Buck's extension traction, which was then its chief application. Its rapid adoption was due to the onset of the Civil War; it became a standard article of equipment in the Medical Corps of the Union army. Davis used elastic traction not only for fractures but also for the treatment of other flexion deformities of the extremities. This technique also was designated in the orthopedic literature of its day as the "American method." Davis received his M.D. at Yale University in 1837 and had his clinical training at Bellevue Hospital in New York City. He settled in New York in 1855, confining his work entirely to orthopedics, including fractures. He applied the American method, brace traction with immobilization, to the treatment of hip disease—"support without pressure, and motion without friction." This method was in complete contrast with the brace immobilization practiced by most of his peers. It remained controversial for decades.

In numbers of troops involved, the American Civil War was the largest military conflict in recorded history to that date. It was then customary for military officers, including medical officers, of friendly nations to be received at battle headquarters and to be permitted to observe the tactics and the armaments. Consequently, American orthopedic innovations which appeared during the 1850s and 1860s soon became familiar throughout European medical centers. In 1844 Josiah Clark Nott (1804-1873), a native of Columbia, S.C., who practiced in Mobile, Ala., published the first reported case of excision of the coccyx for "neuralgia." The term coccygodnia was coined in 1859 by James Young Simpson, 20 years before Friedrich Wilhelm Scanzoni's often quoted book, which popularized the operation.

In 1861 E. S. Cooper of San Francisco contributed the first published

report of fracture of the patella treated by wiring. A similar procedure had been used in the United Kingdom for fracture of the mandible. Cooper's wiring soon became widely known. It is still used in various orthopedic situations.

Before and during the Civil War much research was proceeding in areas which today would be regarded as basic science. Among investigations important to orthopedics were original studies of the response of bone to external stresses. The leading contributions in this field were made by Jeffries Wyman of Boston, who published his first report in 1857. With it he continued the work of Marc-Jeann Bourgery in France, F. A. Ward in England, and Julius Wolff (Wolff's Law) in Berlin.

At this point we encounter the second German orthopedic surgeon to come to the United States fully trained as an expert specialist. He immediately entered competition with Detmold in the small but expanding specialty. Carl August Ludwig Bauer (1814-1898), known to the American medical world as Louis Bauer, was born in Stettin, Pomerania. After various appointments in the German principalities of his day, including, of course, an appointment at Stromeyers' clinic, he went to England and became licentiate of the Royal College of Surgeons. In 1853, at the age of 39, he came to the United States, settling first in Brooklyn. In 1854 he helped to establish there the German General Dispensary, which later became the Long Island College Hospital and Medical School and is now the Downstate Medical Center of the State University of New York. During the same year Bauer joined Richard Barthelmess in starting the Orthopaedic Institute of Brooklyn, the first of its kind in the New York City area. Following the European pattern, it included a garden which contained an outdoor gymnasium. It also had therapeutic baths and an area for the construction of individual orthopedic apparatus. This was all comparable to John Ball Brown's institute in Boston but, coming at a later time, incorporated several improvements. It contained an outpatient clinic and beds for 50 inpatients. After four years of independent existence, Bauer's institute became the orthopedic department of Long Island College of Medicine, chartered in 1858. Bauer remained in Brooklyn until 1869, a fighting contemporary of Detmold, Lewis A. Sayre, Henry Gassett Davis, James Knight, and Charles Fayette Taylor—strong competition in a small specialty. In 1861 Bauer presented a series of

lectures in orthopedic surgery at the Brooklyn Surgical and Medical Institute. In the following year 15 of these lectures were published in the *Philadelphia Medical and Surgical Reporter*. In 1864, after some further editing, they appeared in a book titled *Lectures in Orthopaedic Surgery;* an expanded second edition was issued in 1868. In 1869 Bauer left New York and settled easily in the large German-American community in St. Louis, where his reputation had preceded him. In St. Louis he opened the first orthopedic clinic in the midwest. In 1887 John Ridlon brought orthopedics to Chicago, as later Arthur Steindler brought it to Iowa City. Bauer joined the faculty of the College of Physicians and Surgeons (St. Louis) when it was chartered in 1878. The college closed in 1910. Except for the smaller and less known volume previously published by Buckminster Brown, Bauer's book is usually regarded as the first textbook of orthopedic surgery published in America. A German translation appeared in 1870 and later translations were published in Italy and Sweden.

In his clinical work Bauer was a strong advocate of prolonged bed rest in Pott's disease. He attempted pressure straightening to correct the kyphosis (*brisement forcé*). He was opposed to the use of Taylor's spinal brace, Sayre's plaster casts, and to the American treatment of hip disease. He did not accept the diagnosis of bone and joint tuberculosis or apply the then-popular term "strumous involvement" to skeletal tissues. To him such cases were simply bone disease, hip disease, or Pott's disease—as we might today speak of nonspecific osteomyelitis or pyarthrosis. I do not know Bauer's reactions to Koch's discoveries.

The middle of the 19th century witnessed the establishment of orthopedic surgery as a specialty in the United States, and Lewis Albert Sayre (1820-1900) of New York City was among its giants. He was graduated from the College of Physicians and Surgeons in New York in 1842. Active in the organization of Bellevue Medical College, now the Medical School of New York University, he served as its professor of orthopedics, fractures, and dislocations in 1861. This was the first professional chair of orthopedics in the United States. Later the chair of clinical surgery was added in recognition of Sayre's contributions to the surgical aspects of his specialty. He personally conducted his orthopedic clinic and his hospital service until 1898, when he became emeritus professor and was succeeded by his equally talented son Reginald Hall Sayre.

In 1861 Mayor Fernando Wood designated Lewis Sayre Resident Physician of New York City, the equivalent of City Health Officer. Sayre held the appointment until 1866. He was a charter member of the New York Academy of Medicine, the American Surgical Association, and the American Medical Association. Of the last named, he was the only orthopedic surgeon to attain the presidency. With this prestige, earned by incessant activity in clinics, wards, operating rooms, his private office, and meetings of professional societies and committees, his personal influence became a major force in the development of orthopedics.

Lewis Sayre's influence was manifested chiefly in the transformation of orthopedics from mechanotherapy—the limited realm of the once maligned brace-and-plaster practitioner—into a respected surgical specialty. It took an additional generation to complete the transformation. In 1852 Henry J. Bigelow of Boston (1818-1890) performed the first resection of the hip joint for tuberculous infection. Sayre reported a similar case in 1854 and continued to apply resection thereafter. He is said to have excised more than 70 tuberculous hips in his 30 years of practice. Visiting Europe in 1871, he demonstrated the operation in several surgical centers and was credited with establishing it as a standard procedure. Sayre's reputation in Europe and at home was heightened by the fact that several of his patients were members of the royal families of Norway and Sweden. He performed his resection of the hip as an instructional contribution to the International Medical Congress in Philadelphia in 1876, in the presence of Joseph Lister. At that meeting one of the serious polemics took place between Sayre and Samuel D. Gross, who disputed the etiology of so-called hip disease (coxitis). Gross maintained that it was constitutional; Sayre insisted that it was traumatic. Sayre was often criticized for incising suppurating joints, whereas Bauer and his followers were advocating prolonged bed rest and physiologic supportive measures, and Davis and his group were using the American method of traction by braces. Sayre insisted that the earlier suppurative lesions of joints were recognized and drained the sooner would larger operations become unnecessary. It took 50 years for this opinion to gain acceptance.

Probably Lewis Sayre's greatest contribution to orthopedic surgery was his use of the plaster of Paris jacket, first in Pott's disease and later in scoliosis. In 1874 he applied a plaster jacket to the trunk of a four-

year-old child. This was his first use of the procedure which, with minor modifications, remained known for several decades as the "Sayre plastic jacket." The case was reported in 1876 in the *Transactions of the American Medical Association.* The procedure was complimented and approved in British periodicals by Lister and by the equally influential James Paget of London. When used for scoliosis, the jacket was applied while the patient was suspended by a head halter under an erect tripod. For high thoracic or cervical cases a so-called jury mast —a rod extending above the head and permitting constant head traction—was incorporated in the plaster. The attachment was a forerunner of the "halo" traction of a later generation. Sayre's book *Spinal Disease and Spinal Curvature,* published in 1877, was a leading monograph for several decades. Charles Fayette Taylor of the New York Orthopaedic Dispensary and Hospital (v.) never accepted the Sayre jacket, but at the hospital for the Ruptured and Crippled (now the Hospital for Special Surgery) it was accepted by Virgil Pendelton Gibney (1848-1927) in 1890.

In scoliosis Sayre used lateral pressures to correct the curvature as the plaster jacket was being applied. He would add further pressure correction with each replacement of the plaster. This method has persisted, with modest modifications, to the present time. Sayre's tripod and cloth halter were in constant use, not only in hospital plaster rooms and operating suites, but in the offices of many orthopedic surgeons as late as the 1930s.

For the treatment of spinal deformity Russell Hibbs and his student J. C. Risser later applied the plaster jacket while the patient lay on an operating table, traction of head and pelvis replacing Sayre's overhead halter and gravity. But Sayre's corrective canvas bands later were replaced by wedged plasters with or without anterior and posterior turnbuckles. Repeated reports of committees on scoliosis of the American Orthopaedic Association attested to the improvement in care obtainable by these adaptations of the Sayre jacket. By x-ray confirmation the curves seemed to have been corrected more or less completely. The failures were recurrences that developed after the plasters were removed.

Late in his career Sayre came to believe that apparent reduction in scoliosis treated only by plaster jackets was due chiefly to compensatory curvature rather than to actual correction. His more severely deformed

patients were relatively content with their cosmetic improvement. It must be remembered that Sayre's treatment preceded the advent of x rays, which did not appear until 1898. Not until Russell Hibbs' spinal fusion (1911) was any serious advance in technology available to prevent return of the spinal curvature.

In 1869 Sayre published *A Practical Manual for the Treatment of Club Foot.* This book also appeared in French and German translations. Up to that time and somewhat beyond, untreated or poorly treated cases of clubfoot were common in all strata of society; George Gordon Lord Byron is a famous example. Lewis Sayre was a pioneer in urging that the lesion be recognized and treated at birth or early in infancy and that manipulative treatment and corrective shoes be used. John Ball Brown had expressed the same opinions in his day, but apparently had attracted little attention. Like Sayre, Brown had urged the examination of all newborn children for clubfoot. By Sayre's time, however, orthopedics had become a specialty, with hospital clinics for the poor and a large audience in the medical community; pediatrics also was emerging as a specialty.

In 1871 pressure bandaging with adhesive tape was introduced for the treatment of fracture of the clavicle, and the bandage became known as Sayre's dressing. The dressing pulled the shoulder back, and, by passing around the elbow, pulled the arm up. This too became almost a standard procedure for several decades. It was later superseded by the figure-of-eight bandage and the "clavicular cross."

Lewis Sayre's chief publication was his textbook *Lectures on Orthopaedic Surgery and Diseases of the Joints*, first published in 1876. This text was republished almost immediately in England and appeared on the continent in French, German, and Spanish translations. It superseded Bauer's textbook and remained the most important American treatise for several decades.

Sayre believed strongly that the lesions recognized later as tuberculous infections of the hip and other joints were of traumatic origin or were precipitated by trauma. In the terminology of his day, they were said to be strumous in origin and to depend upon a tuberculous diathesis. But despite his surgical interventions—resection of the hip and incision and drainage of bone and joint infections—he was usually most conservative in the treatment of skeletal deformities and he urged the improvement of mechanotherapy, i.e., braces, plaster of Paris, and

manipulation. Lewis Sayre was made an honorary member of the American Orthopaedic Association in 1889, although he had originally opposed its establishment and had urged his orthopedic colleagues instead to join the American Surgical Association, of which he was a founding member.

Two of America's most prestigious orthopedic hospitals were founded during the Civil War, three years apart. Whereas Brown's and Bauer's institutions were privately operated, the two new hospitals were founded and maintained by self-perpetuating boards of trustees. The two institutions became important in the history of American orthopedics because, along with the Massachusetts General Hospital in Boston, the hospital of the University of Pennsylvania, and the Jefferson Medical School in Philadelphia, they became principal training grounds for the succeeding generation of orthopedic surgeons.

The first of these was the Hospital for the Ruptured and Crippled. Hernia was included in its scope because the orthopedic brace maker also made trusses. The hospital was founded and opened in 1863 by a group of philanthropic citizens organized as the New York Society for the Relief of the Ruptured and Crippled. The first director was James Knight (1810-1887), a Baltimorean who had been practising medicine in New York City since 1835 and for a short time had been an associate of the eminent Valentine Mott. Knight favored the term "surgico-mechanics" to describe his clinical work.

The first staff of the hospital included Valentine Mott, William K. van Beuren, and John M. Carnochan, all leading surgeons. For three years the hospital occupied James Knight's home, but built its own facilities in 1866. Knight remained its chief and active director until 1887, when he was succeeded by Gibney.

Among Knight's important innovations was his introduction of continuing education for children who were long-term in-patients and of vocational training (trade school) for older persons. He also established the first notable program of residency training in American orthopedics. He was a strong advocate of prolonged rest but also was the first to stress the importance of total rehabilitation. Treatment did not stop with arrest or quiescence of the disease in the spine or limb. In his preference for prolonged bed rest he was of course in opposition to Lewis Sayre and his group, who considered Knight excessively conservative. This difference was the principal controversy in American

orthopedics at that time and has retained its primacy until the present; the problem has been solved only in part by the introduction of chemotherapy and antibiotics. Knight also opposed Sayre's plaster jackets and casts for "bone and joint disease." Knight felt so strongly about this that during his ascendancy his great orthopedic center had no operating room. Not until Gibney succeeded him was one installed.

Virgil Pendleton Gibney was born in Kentucky, received his M.D. at Bellevue Hospital in New York in 1871, and was very much influenced by Sayre. In his book *The Hip and Its Diseases* (1884) Gibney accepted Sayre's resection of the femoral head. Knight compelled Gibney to resign from the staff of the Hospital for the Ruptured and Crippled, but, as noted above, Gibney later returned as Knight's successor and remained in charge for 37 years. Gibney was succeeded by Royal Whitman (1857-1946) and for a short time by the latter's son Armitage Whitman. Philip D. Wilson, Sr. (1886-1969), held the post from 1934 to 1955. He was followed by T. Campbell Thompson, then Robert Lee Paterson, Jr., and by Philip D. Wilson, Jr., who occupies the chair in the present bicentennial year. During the tenure of Philip Wilson, Sr., the hospital, in recognition of altered tastes, changed its name to the Hospital for Special Surgery; in addition, it became part of the Cornell-New York Hospital Medical Center. The Hospital for Special Surgery continues to function under the auspices of the New York Society for the Relief of the Ruptured and Crippled.

Charles Fayette Taylor (1827-1899) interested another group of public-minded citizens—including Theodore Roosevelt, Sr., the father of President Theodore Roosevelt—to open a second public orthopedic institution in New York City. This was the New York Dispensary (1866). In 1874 it became the New York Dispensary and Hospital. It is known nowadays as the New York Orthopaedic Hospital and has been affiliated with the Columbia University-Presbyterian Medical Center since 1950. Taylor was its first chief. Like James Knight, he had a strong predilection for the making of braces and mechanical apparatus. An important addition to American orthopedics was his introduction of exercise therapy, then being used in European centers and originally devised by Peter Henry Ling of Stockholm. Taylor's book *The Theory and Practice of the Movement Cure* (1861) was the first effective American report on this subject. The method remained fashionable for a few decades. Interest then was meager until Sister Kenny (v.i.)

revived it for poliomyelitis. It returned after World War II as "corrective exercise" and "functional rehabilitation." At the present time there is an Association of Corrective Therapists outside the organization for physical therapists organized at the end of World War II.

Among Taylor's well-known and lasting contribution to clinical orthopedics was his long spinal brace with shoulder straps. Lighter and far less cumbersome than previous apparatus, it is still known as the Taylor brace. This and the spinal braces of Knight and Joel Ernest Goldthwait (1866-1961) with minor variations are the spinal supports most often used at this time. Taylor held his position as chief of service until 1876, when he was succeeded by Newton M. Shaffer (1845-1928), who had been Knight's assistant when the Hospital for the Ruptured and Crippled was opened, but went to the New York Orthopaedic Hospital shortly after it opened. Both Taylor and Albert H. Freiberg of Cincinnati (1868-1940), first professor of orthopaedic surgery at its University Medical School, advocated prolonged and gradual leverage in the treatment of clubfoot, reviving the methods of John Ball Brown with improved materials rather than by improved therapeutic principles. Their method lost favor for a time, until it was revised by Joseph Hiram Kite at the Shriner's Hospital in Decatur, Ga., in 1933. In 1920 the Masonic Order of the Mystic Shrine had opened its first Hospital for Crippled Children and soon opened others throughout the United States and Canada, especially in rural areas. The first of these was established in Shreveport, La.

As far as can be ascertained, St. Luke's Hospital in New York City was the first major general hospital in the United States to establish an orthopedic service independent of control by the chief of surgery, the organization of hospital services being quite different from the organization of medical school departments. The orthopedic service at St. Luke's was established in 1872 under Newton M. Shaffer, who accepted the responsibility in addition to his work at the New York Orthopaedic Hospital. At about the same time Shaffer also received the professorship of orthopaedics at Cornell Medical School. He was a charter member and early president of the first recorded orthopedic society in the United States, the New York Orthopaedic Society, which eventually became the Section on Orthopedic Surgery of the New York Academy of Medicine. Shaffer was a charter member of the American Orthopaedic Association (founded in 1877) and its second

president. Shaffer was succeeded by Russell Hibbs, Mather Cleveland, and David Bosworth, who in the 1940s and 1950s to a great extent established the treatment of bone and joint tuberculosis by means of antibiotics, starting with streptomycin. The current chief of service at St. Luke's, J. William Fielding, is carrying on its tradition of excellence.

Shaffer rendered important service as chairman of a special committee of the 18th International Medical Congress, held in Berlin in 1890. This congress accepted orthopedic surgery as a recognized specialty in international medicine.

Like Knight, Shaffer remained a mechanotherapist, referring surgical intervention to the general surgeons on his staff. In the orthopedic literature of the 19th and early 20th centuries eponyms were fashionable. A form of deformity, still seen frequently in children and adults –pes cavus with claw toes and no metatarsal inversion or inversion– was described by Shaffer as nondeforming clubfoot and became known in print as Shaffer's foot. It was described in a paper which he published in the *Medical Record* in 1885. Alfred R. Shands, Jr. (v.i.), considered it Shaffer's most important clinical contribution.

Shaffer remained chief of the New York Orthopaedic Dispensary and Hospital until 1891, when he retired and was succeeded by Russell A. Hibbs (1869-1932), who was followed by Benjamin P. Farrell. In 1940, under the direction of Alan de Forest Smith (1891-), the institution became affiliated with the Columbia-Presbyterian Medical Center and in so doing absorbed the famous fracture service of the Presbyterian Hospital. Smith was succeeded by Frank E. Stinchfield who at this writing is one of the country's leading stimulators of research and clinical advancement in orthopedics and the first orthopedic surgeon to become chairman of the Board of Regents of the American College of Surgeons.

In 1897 Minnesota opened the first state-supported hospital for crippled children under Arthur J. Gillette. State-supported institutions then appeared in New York (1900) and in sparsely populated Nebraska (1905). State institutions for the care of the orthopedically handicapped were established subsequently in most of the states of the union, chiefly as repositories for long-term patients transferred from statewide general hospitals which were unable to offer continuous care or for patients living in regions in which no orthopedic surgeons were available. In 1888 Los Angeles County, Calif., established its County Poor Farm.

In 1932 this became the Rancho Los Amigos Hospital for long-term medical care. In 1953, under the direction of Vernon L. Nickel, it has become one of the leading orthopedic centers of the West Coast.

In Boston the progress of orthopedic surgery continued with the high intensity that it had shown in the days of John Ball Brown. Edward Hickling Bradford (1848-1926), a Harvard graduate, spent two years at the usual orthopedic centers in Europe and returned to Boston to enter general practice. He soon became attached to Buckminster Brown and his work. He studied further under Taylor at the New York Orthopaedic Hospital. Returning to Boston in 1876, he was appointed to the House of the Good Samaritan and in 1880 succeeded Brown as its chief orthopedist. He also was admitted immediately to the staff of the Boston City Hospital. Bradford, like Sayre, Knight, Taylor, and their peers, became a giant of American orthopedics; like them, he was the mentor of many of the following generation's leaders.

In addition to clinical contributions, Bradford was involved in community care of the "crippled," who were referred to later as the orthopedically handicapped. In 1894 he established the Boston Industrial School for Crippled and Disabled Children, which was later renamed the Massachusetts Hospital and School for Crippled Children. He was among the first in America to write on static problems in the foot—unexciting but extremely common orthopedic disabilities affecting the daily activities of countless persons. Bradford and Royal Whitman were among the first to bring these problems into focus in the United States. (In 1876 Thomas George Morton of Philadelphia [1835-1923] had coined the term "metatarsalgia," including its occasional complication, "Morton's toe," caused by pressure on the digital nerves; Goldthwait later used the term "prolapsed metatarsal arch.") In 1903 Bradford became the first John Ball and Buckminster Brown professor of orthopaedic surgery at Harvard Medical School; later he became dean. He was among the first in the United States to lengthen tendons by open surgery (1897). This procedure, like Stromeyer's subcutaneous tenotomy, was imported from Europe.

Although sporadic attempts at nerve suture go far back in European surgery, the general introduction of this procedure into surgical practice dates from the American Civil War. Among its early proponents was Silas Weir Mitchell (1829-1914) of the University of Pennsylvania in

Philadelphia, a pioneer of neurology and neurosurgery, whose classic book* appeared in 1872. By the 1880s nerve suture, especially after trauma, was commonly practiced in all developed medical centers. De Forest Willard (1846-1910), first professor of orthopedic surgery at the University of Pennsylvania, introduced nerve suture into orthopedics. Until World War II the procedure was practiced both by orthopedists and by neurosurgeons.

Probably the most original American contribution to orthopedic surgery was that of Berthold Ernest Hadra of Texas (1842-1903). In a case of fracture-dislocation of the cervical spine (C 6-7) he performed open reduction, twisting metal wires around the spinous processes in order to stabilize the injured sector. This operation was performed in 1891 and was reported in the *Medical Times and Register* of that year. Later in 1891 Hadra published in the *Transactions of the American Orthopaedic Association* a longer series of cases, including some instances of Pott's disease. With this publication, the method was disseminated rapidly throughout American and European centers and became recognized as the first attempt at spinal fusion. Other surgeons repeated the procedure, among them Lange of Munich, who tried to improve it by using silk, gut, and other materials in place of wire. Not until Russell Hibbs designed his spinal fusion in 1911 was Hadra's basic technique changed. His procedure of wiring is still required in certain traumatic cases, especially for the cervical spine.

In 1919 the *Transactions of the American Orthopaedic Association* became the *Journal of Orthopaedic Surgery*, later *the Journal of Bone and Joint Surgery*, the official organ of the American and later the British Orthopaedic Associations. *Clinical Orthopaedics* was first issued in 1953. With the *Acta Orthopaedica Scandinavica*, these represent the leading orthopedic periodicals of the late 20th century.

It has been noted already that Bradford of Boston, Shaffer of New York, and Morton of Philadelphia had given great attention to the problem of static foot pain. At the turn of the century Royal Whitman of New York City became interested in the problem, and it formed the subject of one of his first major investigations. His studies of so-called flat feet led him to prefer the term "weak feet." He distinguished between true flat feet—usually a hereditary and in some areas a race-linked condition—and pseudoflat feet, i.e., weak feet. These ailments

**Injuries of Nerves and Their Consequences.* Philadelphia, Lippincott, 1872.

were among the commonest in patients applying for outpatient orthopedic relief during the first half of the 20th century. Whitman designed a special arch support which he considered corrective, rather than merely supportive. Since then many foot supports have been designed; the earlier models were the work of orthopedic surgeons.

Whitman extended his interest to deformities of the feet in poliomyelitis. These cases were numerous at the end of the 19th and first half of the 20th century. In 1901 he devised the operation of "astragalectomy," entire removal of the talus, the foot being thrust posteriorly between the malleoli. He recommended this procedure only for certain types of deformity, such as calcaneovalgus. It remained a leading technique for several decades and was often used in other types of deformity or trauma of the foot. In 1913 G. G. Davis of Philadelphia devised subtalar fusion, which quickly became competitive with Whitman's astragalectomy. The fusion operation has been modified, with and without improvement, by Michael Hoke of Atlanta, Edwin W. Ryerson of Chicago, and others, and has led to triple arthrodesis of the talus. As poliomyelitis receded in the United States these procedures became less noteworthy.

During a span of approximately 50 years an important part of orthopedic surgery was the elongation and transplantation of tendons. This was largely an importation from Italy and Germany. Although the method had been tried sporadically in the United States almost immediately after its introduction by Karl Nicoladoni, a native of Innsbruck in the Austrian Tyrol, in 1880, the basic technique which is now in use was introduced into the United States by Parrish of New York City in 1892. It soon became popular. Goldthwait was using it in Boston by 1895 in transplanting hamstring tendons for paralysis of the quadriceps muscles, a common disability in poliomyelitis. Milikan was using tendon transplants at the same time. These three men may be said to have introduced tendon transplantation into the United States in the late 1890s and early 1900s. Painter continued to spark Boston's interest. By 1917 Samuel Kleinberg of the Hospital for Ruptured and Crippled in New York City was able to report 23 cases of successful transplantation of the biceps.

One of the causes of failure in surgery of the tendons—probably the chief cause—was postoperative adhesions of gliding surfaces. To some extent, Codivilla in Italy had solved this problem by retaining

the sheaths of the inactive tendons and passing the transplanted tendon through them. Leo Mayer, who had been working in Germany, brought this method to the United States in 1917. Upon his return to New York he joined the staff of Fred H. Albee (1870-1945) at the Postgraduate Hospital, later merged into New York University-Bellevue Medical Center; soon afterward he worked at the Hospital for Joint Diseases, founded by Henry Frainenthal in 1907. He immediately published in *Surgery, Gynecology and Obstetrics* a series of three papers on the new method of using tendon sheaths to preserve the gliding surfaces and quickly revitalized interest in tendon surgery.

In 1911 D. Lewis and C. B. Davis introduced the use of fascia as a substitute for tendon; it also could be used to reinforce tendons or to lengthen them. This method, too, was a German importation and is credited mainly to Erich Lexer. Where sheaths were not available or were unusable to preserve the gliding surfaces of tendons, other substances were sought. In 1901 Williams of Colorado first tried egg membrance. Leo Mayer and Nicholas Ransohoff tried celloidin in the 1930s. The problem of poliomyelitis contractures of the hip joint drew much attention during this period, and a number of ingenious types of muscle and tendon transplantation were devised by Frank R. Ober in Boston, Willis C. Campbell in Memphis, and Lewis Clark Wagner and Peter Cyrus Rizzo in New York City.

Of the vast number of transplantation methods devised, modified, and forgotten during this half century, transplantation of the femoral biceps with or without the medial hamstrings remained one of the commonest until poliomyelitis was reduced to a low level of incidence by the introduction of the Salk and Sabin vaccines in 1954 and 1960, respectively. This solution of one of the most serious problems in orthopedics was an American contribution. After this period, the problems of tendon transplantation and tendon surgery were almost entirely in the domain of hand surgeons.

Injuries to the hand suffered relative neglect. This was true for several social and professional reasons. These lesions were far less dramatic than the more extensive injuries of the larger bones and joints, civil or military. In earlier years there was no mass population of factory workers whose livelihood depended on digital agility. In the United States serious concern started with Allan B. Kanavel of Chicago (1874-1938). His book *Infections of the Hand* (1933) was a classic

of surgical and orthopedic literature. The work was continued by Sumner L. Koch and M. L. Mason and led to the massive contribution by Sterling Bunnell of San Francisco (1882-1957). The first edition of Bunnell's *Surgery of the Hand* appeared in 1944 after two decades of study and preliminary publication; it became the bible of hand surgery. Before chemotherapy, the only disease of the hand that attracted much attention was infection, which might lead to amputation of a limb or to death from septicemia. During World War II studies by the United States Army Medical Corps showed that some of the worst surgical results were those obtained in injuries of the hand. The Surgeon General, European Theater of Operations, ordered that such injuries be segregated and assigned to a single orthopedist if one was available or to a general or plastic surgeon. Within a month the difference in results was apparent. Bunnell's book furthered this trend. These influences stimulated the development of surgery of the hand as a recognized subspecialty, which has its own society that meets annually as part of the Convention of the American Academy of Orthopedic Surgery.

On January 9, 1911 Hibbs performed an operation designed to fuse and thereby stabilize a section of the vertebral column in a patient who had Pott's disease. He overlapped the spinous processes and removed cartilaginous surfaces from the intervetebral joints. In the same year he described the operation and suggested its use for scoliosis. A report which he published in 1914 included cases of both Pott's disease and scoliosis. In 1911 Albee, knowing of Hibb's operation, attempted to fuse a spinal sector by use of his popular bone-grafts technique, which employed grafts of the tibial cortex. Partly because of Albee's worldwide reputation for bone grafting, the two procedures ran parallel for about a decade, but the Albee operation eventually gave way to Hibbs' technique and its later modifications. Between Hadra's concept of stabilizing the spine by means of wires and Hibb's fusion method, control of spinal deformity came to be another of America's major contributions to orthopedic surgery.

Poliomyelitis scoliosis was one of the most tragic and difficult problems in the realm of orthopedics. During the 1930s Charles Le Roy Lowman of Los Angeles attempted to control the deformity by transplantation of fascial strips in order to stabilize the vertebral column. Although this procedure did not prove markedly successful, it started an original American interest in the use of fascia as adjuvants in the

surgery of muscles and tendons. As time passed, Hibbs, as well as Frank R. Ober and Samuel Kleinberg—strong advocates of the Hibbs spinal fusion—found less urgency for the operation and confined its use to cases in which the scoliosis was progressing rapidly. John Cobb of the Hospital for Special Surgery, after studying more than 2,000 cases of scoliosis, reported definitively in 1943 that in the great majority of cases the disability showed little or no tendency to advance, hence fusion was not needed. Cobb's studies were based on a system of measurement which had been suggested to him by Robert K. Lippmann of The Mount Sinai Hospital of New York.

From 1911 to the 1940s Knight's spinal brace (1884) and Taylor's brace (1899) were the supports most often used for scoliosis. In 1946 Walter P. Blount of Milwaukee and his associate Albert C. Schmitt devised the first innovative change in the treatment of scoliosis since the work of Hibbs. Blount and Schmitt used a form-fitting brace with overhead traction. This device, known as the halo brace or Milwaukee brace, was intended to be worn day and night. It was, of course, an advance on the jury masts of the 18th century and it began a new era in the treatment of scoliosis. The halo brace could be used preoperatively and postoperatively when spinal fusion was indicated. This system was continued and improved by Blount's successor, John H. Moe. While it was being developed in Milwaukee, Paul R. Harrington of Houston, Texas, during the 1950s and early 1960s was developing a metal rod-and-screw device to be inserted along the spinal column and elongated repeatedly to correct the scoliosis mechanically. Both systems are now at the focus of studies on scoliosis.

Low-back pain with or without sciatica has plagued the human race since the beginning of history or earlier. During the 19th century more commercial advertising was devoted to cures for lumbago or sciatica than to any subject other than impotence. The first truly surgical approach to severe disabling backache and sciatic syndrome was made when Marius Nygaard Smith-Petersen of Harvard in 1921 accepted the then-controversial hypothesis that the sacroiliac joints are involved. In 1921 he proposed fusion of the sacroiliac joint. This procedure was soon accepted by Willis C. Campbell of Memphis and by John W. Ghormley of the Mayo Clinic. The operation was in high vogue for a decade, until in the early 1930s Isidore Zadek noticed during his ward rounds at the Hospital for Joint Diseases that relief from pain was often

almost immediate after surgery, even though it might prove transient. He then hypothesized that the relief might have been derived not from fusion but from the release of tight muscles. This suggestion was followed by a short period during which muscle-releasing procedures were in vogue.

In 1911 Joel E. Goldthwait of Boston and George S. Middleton and John H. Teacher of Glasgow had described independently the pathology of posterior herniation of discs into the spinal canal. This had been described previously by Rudolf Virchow, Theodor Kocher, and others on the basis of autopsy findings alone, but had not been correlated with clinical symptoms until the studies that have just been mentioned. Goldthwait's contribution was part of his intensive study of static lesions of the lumbosacral spine. Finally, in 1934 came the classic paper by the neurosurgeon William J. Mixter and the orthopedic surgeon Joseph S. Barr, both of the Harvard Medical School and the Massachusetts General Hospital, on surgical extirpation of herniated discs. This contribution transformed the entire subject of lumbago and sciatica. Earlier optimism having somewhat faded with long-term follow-up, discectomy is now reserved for the more persistently disabling cases. Another solution to the disc problem, chemonucleosis, was introduced by Lyman Smith of Elgin, III. This procedure consists of the direct injection of a substance intended to reduce the size of the projecting nucleus pulposus. The controversial method is now under study. The entire subject of spinal fusion and surgery of discs originated in the United States; it has benefited from work done in other countries, especially Japan, and by A. R. Hodgson of Hong Kong.

The treatment of fracture of the long bones, a combination of traction and plaster of Paris immobilization, remained standard through the early decades of the 20th century until the introduction of fixation by metal bone plates and screws. This method probably originated in Belgium and then was widely popularized by the British. It was introduced into the United States by several surgeons, most effectively by W. O. Sherman of San Francisco (1912). However, the high incidence of postoperative infection and of loosened screws made the procedure risky and most surgeons continued to prefer the safer nonoperative approach. To a great extent this was changed in 1938, when John Manning Venable and Walter G. Stuck of Texas introduced the nonelectrolytic metal Vitallium, an alloy of cobalt, chromium, and molyb-

denum. The material was not new; studies of the electrical potential of metals in human tissues had been in progress since at least 1908. The application to skeletal surgery was the catalyst which caused a major change not only in the surgery of fracture but also in arthroplasty. This preceded World War II by a few years. By that time steel manufacturers had developed the ferrous alloy 18-8SMO, which was said to have the same nonelectric property as Vitallium. The Anglo-American forces of World War II used these materials interchangeably for the fixation of fractures until wounded German prisoners were received from their hospitals with intramedullary nails devised by the Austrian Gerhard Küntscher. On their return from Europe, American orthopedic surgeons quickly introduced this method into practice.

Until the advent of chemotherapy and antibiotics, the chief problem in open fractures, whether primary or surgical, was infection. The incidence of osteomyelitis had been 80% in World War I and was reduced to 25% in World War II.

The period of World War I witnessed the first serious attempt since the 16th century to avoid infection in open fractures. Alexis Carrel and Henry D. Dakin tried repeated irrigation of the wound with special antiseptic solutions. Then Winnott Orr of Lincoln, Neb. (1877-1957), serving with the American Expeditionary Force (AEF) in France, noted that the wounds of French fracture patients, dressed much less often than those in Anglo-American hospitals, seemed to heal better, in spite of soiled and maggoty dressings. With this observation began the period of the Orr treatment of osteomyelitis, traumatic or hematogenous, carried on in the United States for several decades until the introduction of chemotherapy. The method consisted of thorough debridement of the wound and wide saucerization of infected bone. The wound was then packed with vaseline gauze (later fine-mesh gauze was used without vaseline), and the limb was kept in plaster until it stank beyond tolerance. Then the wound was dressed again in the same way and replaced in plaster. This continued until the wound had granulated "from the bottom up." This method had been used by Pirogoff in the Russian wars of the 1850s but had been forgotten. With the surgical experiences gained in the subsequent 70 years, wide debridement and extensive saucerization became feasible and Orr's treatment became the American choice.

A rather bizarre and almost incredible by-product of Orr's method

must now be mentioned. Walter S. Baer of the Johns Hopkins Hospital in Baltimore had been interested in the methods used by the French army for the treatment of wounded extremities. He was impressed especially by the apparent therapeutic quality of the maggots. After World War I he cultivated maggots and applied them to debrided wounds in osteomyelitis. In cases of fracture this was done through a window cut in the plaster cast. At the Hospital for Joint Diseases in New York City a special laboratory was maintained for the cultivation of maggots. The vogue lasted for a few years in both institutions.

With the rapid development of mechanical industry and rapid transportation after World War I, fractures began to assume proportions in civil life heretofore known only on the battlefield. In 1917 Charles Locke Scudder of Boston established at the Massachusetts General Hospital the first hospital service organized specifically for the treatment of fractures. Although resisted by general surgeons and general practitioners, the idea spread rapidly through the major hospitals of the United States. In large institutions these departments remained separate from departments of general surgery and orthopedics in the interwar period, but, with few exceptions, they were merged with orthopedic services after World War II. The long duration of this organizational problem (1917-1947) was due to medical staff politics, economics, and personal vendettas. It also was the period of formation of American specialty boards. The American Board of Orthopedic Surgery was founded in 1934. In the military services during World War II and thereafter under workmen's compensation boards, fractures were allocated officially to orthopedic surgeons when such men were available.

In 1922 a conference led by Scudder at the Massachusetts General Hospital issued an *Outline of the Treatment of Fractures;* this became the official manual of the American College of Surgeons. Shortly thereafter a national Committee on Fractures (and regional subcommittees) was established by the college; later it became the Committee on Trauma.

A startling American development was the "hanging cast" devised by Gene D. Caldwell of Shreveport, La. (1933). This device replaced the cumbersome age-old plaster spica in the treatment of fracture of the humerus. Its wide acceptance was due to its usefulness in the transportation of wounded soldiers.

In the late 1930s the sulfonamides were introduced into surgery.

Followed by the antibiotics in the 1940s, these drugs greatly influenced surgical judgment and produced a liberation of methods in orthopedics as in almost all other branches of clinical practice. During the sulfonamide period drugs were used not only orally but topically in orthopedics; this was due to the studies of J. Albert Key of St. Louis and W. C. Campbell of Memphis and the army orthopedic surgeon at Ft. Monmouth, N.J. As a topical application, sulfonamide became the memorable "star-dust" of the Anglo-American armies of World War II. With the defense against fatal septicemia afforded by chemotherapy and antibiotics, bolder skeletal surgery became possible.

During World War I Joseph Blake and Eugene Poole, working with the AEF, introduced the principle of secondary or delayed suture. This was directly opposed to the Orr treatment. The reports of Blake and Poole were buried in the official medical history of the war and were forgotten. In 1943 American orthopedic surgeons in North Africa began the plating of open fractures and, under cover of topical sulfonamide and later penicillin, began to practice delayed primary suture. After the war this was continued in civilian practice until the acceptance of the intramedullary nail.

In the 1880s Joseph Ransohoff of Cincinnati (1853-1921) had designed ice tongs for skeletal traction in fractures and for other purposes, but these were discarded in favor of the more efficient Steinmann pin.

During most of World War II the surgeon general of the United States army was Maj. Gen. Norman T. Kirk. He was a professional medical officer who had done excellent work on surgical amputation and subsequent rehabilitation. At the Walter Reed Hospital in Washington, D.C., he established the first military orthopedic service in the United States. Among his notable methods was that of early "peg leg" ambulation after amputation of the leg.

During a short but active period, a system of external fixation was used. It was introduced for the treatment of fracture by Roger Anderson (1932), O Stader (1937), and H. H. Haynes (1939). Anderson's apparatus, the first to appear, was used widely; it was popularized by Philip D. Wilson, Sr. Wilson took the device with him to England with his American orthopedic unit before entry of the United States into World War II. Except by its originators and a few of their associates, the use of external fixation for fractures was soon discontinued

almost entirely. It is still employed in dental and maxillofacial surgery.

Until the early 20th century, the treatment of fracture of the femoral neck—colloquially referred to as fracture of the hip—was considered futile. In the mid-19th century Astley Cooper, the English master surgeon, was of that opinion. He recommended bed rest until acute pain subsided and then return to ambulation "with a walking stick" as tolerated. No important attempt to treat this severe disability was offered until 1902, when Royal Whitman manipulated the reduction of the fragments under x-ray control and applied a long leg-spica cast. Subsequent nursing care included exercise of the free limbs and frequent turning of the patient in bed to avoid hypostatic pneumonia. For the surviving failures of this method, patients whose fractures failed to unite, Whitman devised his first reconstruction operation of the hip (1921). He removed the necrotic femoral head, transposed the trochanter distally, and placed the remainder of the femoral neck in the acetabulum. This operation, also used later for arthritic degeneration of the femoral head, modified by Paul C. Colonna, Samuel Kleinberg, Elliot G. Brackett, and others, was used until the invention of internal fixation.

In 1850 Bernard R. K. von Langenbeck had attempted to fix fractures of the femoral neck by inserting a nail through the trochanter. For 70 years others had repeated this procedure, using nails, screws, ivory pegs, and bone rods of various kinds. All failed. To a large extent the problem of the fixation of fractured hips was solved when Marius Nygaard Smith-Petersen (1886-1953) of the Massachusetts General Hospital recognized that the failure had been caused by rotation of the femoral head around a single surface. He designed a three-flanged nail which prevented such rotation. The Smith-Petersen nail was introduced in 1925, and soon gained universal acceptance. Austin Moore modified the procedure by using multiple thin screws (1934), as did David Telson and Nicholas Ransohoff (1935) at the Hospital for Joint Diseases. Smith-Petersen first inserted his nail under direct vision by open exposure of the hip. In 1932 he demonstrated his method to his friend and colleague Johannson of Stockholm, who suggested the closed insertion of the nail under the guidance of x-ray equipment brought into the operating room. Independently and in the same year, H. H. Westcott of Roanoke, Va., invented the same x-ray control of "blind nailing" for fractured hips.

This method became standard practice almost immediately. Most fractured hips healed when properly nailed or held by screws. Successful union, however, did not prevent subsequent avascular necrosis of the femoral head. When this occurred to the point of painful disability, Whitman's reconstruction operation or one of its several modifications had long been used in order to provide at least a modicum of stability. At about this time Robert K. Lippmann of The Mount Sinai Hospital in New York City introduced a screw-bolt designed for both fixation and impaction of the fracture surfaces.

It was apparent early that the Smith-Petersen nail and its variants were effective in fractures of the femoral neck but would not hold the equally serious intertrochanteric fracture of the hip. In 1937 Lawson Thornton of Atlanta attached a bone plate to a Smith-Petersen nail and fastened the plate to the adjacent femoral shaft. This device held the fracture. It was soon followed by other "blade plates" for intertrochanteric fractures designed by Blount, Newfeld, Austin Moore, Jewett, McLaughlin, and others.

Despite these innovations, avascular necrosis of the femoral head continued to be the major unsolved problem in fractures of the hip, reducing the healing rate of 80% to a failure rate of 50%. In the 1960s this figure was revised upward by a British orthopedic surgeon who advocated statistical differentiation between displaced and undisplaced fractures of the hip. When undisplaced fractures were counted as a group the failure rate dropped below 50%.

In 1925 Smith-Petersen attempted cup arthroplasty for avascular necrosis occurring after fracture of the hip and for degenerative osteoarthrosis. He reshaped the femoral head and covered it with an impermeable material. His final choice for this purpose was Vitallium.

In 1919 a rubber mold had been tried in an attempt to replace the degenerated femoral head. This French innovation was introduced by Delbet and his confreres. Although it failed, as did trials with other materials, this marked the introduction of endoprostheses. In 1943 Austin T. Moore and Harold R. Bohlman of South Carolina, using nonelectrolytic Vitallium, devised an endoprosthesis equipped with an intramedullary stem to replace the upper half of a resected femur. The result obtained in their first case was reasonably good and inspired additional attempts to replace the femoral head. Soon after World War II an acrylic endoprosthesis developed by the Judet brothers of Paris became

extremely popular in the United States. In this prosthesis the stem of the head passes through the trochanter. This method did not prove successful in the long run. It aroused the enthusiasm of the MacAuslands of Boston and others and was questioned by Philip Wilson, Sr. It soon gave way to the stem type used by Moore and Bohlman. Of many designs then offered—at one meeting of the American Academy of Orthopaedic Surgeons 57 designs were exhibited—that of Frederick R. Thompson of St. Luke's Hospital, New York City, later modified by Moore, remained the standard endoprosthesis for replacement of the hip. By 1953 a committee of the American Academy of Orthopaedic Surgeons reported 6,156 cases in which this treatment had been used and the Thompson-Moore prosthesis became the prescribed procedure in orthopedic surgery.

The concept of arthropasty started with John Rhea Barton of Pennsylvania, but the technical procedure was developed chiefly by Italian and German orthopedic surgeons. John B. Murphy of Chicago is recognized as the first to cover the reconstructed articular surface with interposition material to prevent refusion. H. Helferich in Germany had tried a pedicle flap and Murphy tried layers of fatty fascia from 1902 to 1914. In 1909 William S. Baer of Baltimore came to share the widespread interest in interposition arthroplasty. During the 1920s and 1930s this subject became fashionable in American orthopedic surgery but the results were less successful than the prevalent optimism suggested. Endoprosthesis, originally used in the hip, was later applied to other joints.

Early in the 1960s John Charnley of Manchester, England, introduced total endoprosthesis, using metals and acrylics on both articular surface and acrylic cement to hold the prostheses to bone. The cements were intended to fasten the endoprosthetic elements in order to prevent rotation, loosening, and absorption of bone. At this writing total prosthesis for the restoration of joints is the topic of most active interest in the world of orthopedics. Charnley's method was introduced into the United States almost simultaneously by Frank Stinchfield of the New York Orthopedic Hospital and Robert Lee Patterson of the Hospital for Special Surgery. At the latter institution it was carried on by Philip D. Wilson, Jr.

Although sporadic attempts at bone grafting date back to England, France, and the Netherlands of the 17th century, as an effective pro-

cedure of wide application the method started with Frederick Albee (1876-1945) of the Postgraduate School of Medicine in New York. Albee used autogenous bone, carefully measured and taken from the cortex of a long bone, usually the tibia, inserting it into a prepared cancellous bed at the site of nonunion or into some other area if this was necessary as a supplement in fusion operations. He referred to the work of Sir William MacEwen of Glasgow, who frequently used bone chips obtained at osteotomies for rachitic bowleg. The fragments were employed for maintaining correction and reparative osteogenesis. He also mentioned Louis Xavier Ollier of France, who also had tried the method. Albee devised the first electric bone saw which could be sterilized and he vastly improved the accuracy of "bone-graft carpentry." He also suggested that inlay grafts be fitted firmly instead of merely being placed over or between bony surfaces. Albee was a widely traveled surgeon and frequent speaker; this may have aided acceptance of the "Albee graft." His textbook, *Bone Graft Surgery* (1915), was a principal source of reference for several decades. The use of cortical grafts continued until the introduction of cancellous grafts by Le Roy Abbot, J. B. Saunders, and F. C. Bost in 1942.

Bone lengthening—a procedure frequently attempted after the great poliomyelitis epidemics of the early 20th century—imported from Italy in 1908 by Paul B. Magnusson, then of the University of Pennsylvania, and in 1912 by Albert H. Freiberg of Cincinnati. The method consisted of osteotomy followed by prolonged traction. The frequent failures were due to inability to maintain the adjacent bone ends in contact. The first attempt, performed with traction, was recorded by Alessandro Codivilla of Bologna in 1912. Magnusson published his American cases in 1913. Le Roy Abbott of St. Louis worked on the problem for several decades and devised the four skeletal traction pins used to hold fragments in proper alignment. Equalization of length by resecting part of the bone of the longer limb antedated lengthening; it was imported into the United States from Europe. A third approach to inequality of length, applicable only to growing children, was that of surgical interference with epiphyseal growth, introduced in 1933 by Dallas B. Phemister of Chicago. This procedure is called epiphysiodesis.

To a large extent, the subject of bone tumors was one in which American orthopedics and pathology combined their efforts. As early

as 1879 Samuel W. Gross of Philadelphia, the son of Samuel David Gross, his predecessor as professor of surgery at the Jefferson Medical College in Philadelphia, published an extended review of bone sarcoma. This paper appeared in the *American Journal of Medical Sciences* and received wide and favorable notice in American and European texts and journals.* Fielding Garrison, the master of American medical history, acclaimed it the first serious contribution to the subject. Isolated cases of this neoplasm had been reported under various names in the United States. One of the earliest on record was that by Valentine Mott, who resected an involved clavicle early in 1828.

The second important contribution of American orthopedics to the study of sarcoma dates from 1921. In that year Ernest A. Codman of Boston, under the aegis of the American College of Surgeons, developed the first organization of a kind that subsequently was imitated in other fields, the Registry of Bone Sarcoma. From then on interest in bone tumors spread widely in the United States and attracted such eminent pathologists as James Ewing of Bellevue Hospital, Paul Klemperer and S. Otani of The Mount Sinai Hospital, Louis Lichtenstein of the Hospital for Joint Diseases (later California), and Charles F. Geshikter and M. M. Copeland of Johns Hopkins Hospital. Joseph Colt Bloodgood of Baltimore (1867-1935) described a difficult neoplasm known as giant cell tumor of bone. His work was later continued by Jaffe. Ewing described an equally complex malignant bone tumor which still bears his name along with a multiplicity of names, including reticulum-cell sarcoma. Ewing credited the recognition of this neoplasm to Gross' classic review, but he felt that the entity had not been isolated sufficiently. Bloodgood also isolated myxomas of bone in 1920, Otani isolated eosinophilic granuloma, and Jaffe described osteoid osteoma in 1937. Interest spread widely in orthopedic circles with the publication of American textbooks on bone tumors by Geschikter and Copeland of Baltimore and Jaffe in New York City.

William Bradley Coley (1863-1936) noted that some bone sarcomas apparently receded during attacks of erysipelas, a frequent infection in the days preceding chemotherapy. For several decades he and his son Bradley Coley treated these tumors by introducing controlled streptococcus infections. This work was done chiefly in the

*Sarcoma of the long bones, based upon a study of one hundred and sixty-five cases. *Amer. J. Med. Sci.* (n.s.) *78*:17-57, 338-77, 1879.

bone-tumor service of the Hospital for the Ruptured and Crippled. Much later it was learned that James Paget of London had recognized the phenomenon but had done nothing about it. Coley's serum was never entirely forgotten, although it was dormant for some time. At this writing the possibility of an infectious origin of bone sarcoma, which occasionally presents multiple sites of apparent origin, has again come under investigation in the United States.

In the 1930s the attention of American orthopedists was drawn to the equally malignant soft-tissue sarcomas of the extremities. Up to that time the diagnosis of fibrosarcoma of an extremity called for immediate amputation. Papers published in 1935 and 1938 from the orthopedic service of The Mount Sinai Hospital of New York City showed that early and complete excision was followed by survival in 50% of cases, and that in no case did metastasis occur before local recurrence. This was confirmed by a report from the Mayo Clinic about 25 years later.

American orthopedic studies on generalized skeletal disease usually kept pace with European discoveries, especially after the introduction of the x ray in 1898. In 1910 Arthur T. Legg (1874-1939) of Boston differentiated a lesion of the hip joint in children from the common cases of tuberculosis of the hip; G. C. Parthes followed later the same year. Eponymic diseases of the skeleton flourished at this time, including Osgood's disease of the tibial tubercle and Freiberg's disease of the metatarsals. These all belonged to a pathological group which Joseph Buchman in 1927 linked as the osteochondritides. Since the lesions were not inflammatory, Beckett Howorth preferred to designate them as osteochondrosis.

J. Albert Key of St. Louis advanced the subject of fragilitas osseum (brittle bones). In 1926 Joseph S. Barr and his associates studied the relation between osteitis fibrosa cystica and hyperparathyroidism. In 1931 Jaffe reproduced the disease in rabbits by the injection of parathormone. In 1893 Alfred Hand of Philadelphia described the syndrome of exophthalmos, polyuria, and soft spots in the skull. Similar reports were later issued by Henry A. Christian of Harvard University and by Arthur Schüller in Germany. These special case reports led to recognition of the group of skeletal diseases now classified under the term "lipoid granulomatosis." During the early part of the 20th century these had had the name of Hand-Schuller-Christian's disease. In 1942 Albert

J. Schein and Alvin M. Arkin of New York noted the clinical effects of osseous involvement by Gaucher's disease, especially in cases thought to be examples of Legg-Porthe's disease. Christian previously had noted bone involvement in Gaucher's disease but had not shown any clinical relation.

The subject of internal derangement of the knee joint, one of the most popular topics in orthopedics, originated largely from British contributions. However, American additions have been of some importance. Goldthwait brought meniscectomy to the United States from England in 1900. In 1904 he split and replaced the patellar tendon for recurrent dislocation of the patella. The introduction of corticosteroids by P. S. Hench of the Mayo Clinic in 1949, and especially the advent of intra-articular hydrocortisone by Joseph L. Hollander, the American rheumatologist (1951), has led to increased nonoperative care of internal joint derangements, a disease in which painful periods are often due to secondary synovitis.

Since World War II several nationwide tendencies in orthopedic surgery in the United States, as in other specialties, have altered their direction. In 1929 and 1930 the first full-time fellowships in orthopedic pathology were established at the Mayo Clinic, the Hospital for the Ruptured and Crippled, and the New York Orthopedic Hospital. Until that time pathology was the basic science of clinical orthopedics. During the 1950s other scientific disciplines were brought into the laboratories of orthopedic hospitals and the orthopedic departments of larger medical centers. In 1954 the Orthopaedic Research Society was founded for the purpose of developing interest in pure scientific research. During this period the great leap forward was the program of attracting young orthopedic surgeons to full-time appointments for basic research and at times for the administration of orthopedic services from their perch in the laboratory. Among the pioneers in this transformation are Marshall R. Urist of Los Angeles, C. Andrew Bassett of New York, Jonathan Cohen and Henry J. Mankin of Boston, and Robert D. Ray of Chicago.

Another decisive development of the 1960s and 1970s was the appearance of subspecialty organizations affiliated with the American Academy of Orthopaedic Surgery but interested in fostering progress in their own areas of investigative interest. This, of course, was a response to the highly technical advances, both in basic science and oper-

ative procedures, which appeared rapidly at this time in orthopedics and in other branches of medicine. The Society for Surgery of the Hand appeared at about the time of United States entry into World War II. The Orthopaedic Research Society was formed in 1954. Organizations which arose during the 1960s and 1970s include the American Society for Sports Medicine, whose first president was the pioneer Don O'Donohue of Oklahoma, the American Orthopaedic Foot Society led by Robert Joplin of Pennsylvania, the Hip Society organized by Frank Stinchfield, and the Scoliosis Research Society founded in 1966 with John H. Moe as its first president. Along with this trend, the Orthopaedic Nurses Association was founded in Atlanta, Ga., in 1972.

Orthopedic surgery had been considered unsuitable for women because of the physical stringencies of certain of its procedures. In the middle third of the 20th century this bar was broken. Among the pioneers were Mary Sherman of the Ochsner Clinic of New Orleans, Ruth Jackson of Waco, Texas, and Jacqueline Perry of Rancho Los Amigos of Downey, Calif.—all of whom gained national recognition.

ACKNOWLEDGMENT

I thank Helen L. Kleinwechter, O.N.A., for editorial assistance.